IN THE DRAWINGS

Corrected drawings are supplied herewith, each labeled as "REPLACEMENT SHEET." No amendments are made to the drawings; therefore no new matter has been added.

REMARKS

This responds to the Office Action mailed on November 16, 2005.

Claims 1, 15, and 22 are amended; no claims are canceled; and no claims are added. As a result, claims 1-30 are now pending in this application.

Interview Summary

Applicant thanks Examiner Kevin Y. Kim for the courtesy of a telephone interview on April 14, 2006 with Applicant's representative Bruce E. Houston. In the current Office Action, Examiner Kim requested an explanation of a method or structure for determining the reduced alphabet disclosed in the Application:

> According to the specification, a 'reduced complexity equalizer' generates an output signal and the reduced alphabet determination unit is said to identify a subset of symbols that are more likely than other symbols. Since no detail of how this determination was not [sic] disclosed, a question was raised in the previous Office actions... A reasonable explanation of a way the determination is made would overcome this rejection of the pending claims. Office Action of November 16, 2005, pg. 2, para. 1.

Mr. Houston reviewed with Mr. Kim two cases disclosed in Applicant's specification relating to the means of identifying a reduced alphabet. In a first case soft symbols are identified from a communication channel. In a second case hard symbols are identified from the communication channel. Mr. Houston pointed Mr. Kim to Applicant's specification, pg. 5, lines 19-26, and read these lines to Mr. Kim, as follows:

> The reduced state MLSE equalizer 32 processes the communication signal to generate a plurality of soft symbols at an output thereof. Each of the soft symbols has a probability associated with it that represents the probability that the soft symbol is the actual symbol that was transmitted (i.e., for a particular input symbol). The soft symbols are delivered to the symbol selection unit 34 which selects the K most probable symbols from the soft symbols (where K is a positive integer). The K most probable symbols are then output as the reduced alphabet to the reduced alphabet MLSE 36.

Mr. Houston reviewed with Examiner Kim the concept of soft symbols. Examiner Kim acknowledged that he understood that a soft symbol or soft bit is a vector-like quantity with a magnitude and a direction. The direction represents the state of the symbol or bit, e.g., a group of ones and zeros, or a phase of an electrical signal representing a particular combination of ones and zeros, for example. The magnitude is a real number representing a probability, a likelihood, or a reliability associated with the symbol. Mr. Houston further explained to Examiner Kim that the enabling statement "[t]he soft symbols are delivered to the symbol selection unit 34 which

selects the K most probable symbols from the soft symbols" discloses the process of creating a reduced alphabet by selecting a subset of symbols using a probability value inherent with each soft symbol.

The real numbers representing probabilities associated with the reduced alphabet subset are indicative of higher probabilities than real numbers associated with symbols not selected as members of the reduced alphabet. Thus, as explained to Examiner Kim, the symbol probability information comprising the reduced alphabet selection criteria is attached to each symbol in the form of a real number as the symbols arrive at the symbol selection unit 34. The symbol selection unit 34 "selects the K most probable symbols" by comparing the real number representing the probability of each symbol equalized by the reduced complexity (the first) equalizer against the real numbers probabilities of all the other symbols equalized by the reduced complexity equalizer.

Mr. Houston further directed Examiner Kim to the enablement section of Applicant's Specification relating to the case of hard symbols, and read the following passage at pg. 6, lines 10-16, referring to FIG. 3:

> [T]he equalization system 40 includes a hard decision equalizer 42, a symbol selection unit 44, and a reduced alphabet MLSE 46. An optional alphabet size determination unit 48 may also be provided. The hard decision equalizer 42 processes the communication signal to generate a hard symbol for each of the input symbols. *The symbol selection unit 44 then selects the K-1 symbols from the full alphabet that are closest in distance to the hard symbol.* These K symbols are then output as the reduced alphabet. (Emphasis added.)

Following these discussions, Examiner Kim asked Mr. Houston to respond to the instant Office Action, and Mr. Houston acknowledged that he would.

§*112 Rejection of the Claims*

Claims 1-30 were rejected under 35 USC § 112, first paragraph, as failing to comply with the enablement requirement. According to the Office, the claims contain subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

The Office requests an explanation of a method or structure for determining the reduced alphabet disclosed in the Application:

> According to the specification, a 'reduced complexity equalizer' generates an output signal and the reduced alphabet determination unit is said to identify a subset of symbols that are more likely than other symbols. Since no detail of how this determination was not [sic] disclosed, a question was raised in the previous Office actions... A reasonable explanation of a way the determination is made would overcome this rejection of the pending claims. Office Action of November 16, 2005, pg. 2, para. 1.

As discussed in the aforementioned interview with Examiner Kim, Applicant's Specification recites two cases relating to the means of identifying a reduced alphabet. In a first case soft symbols are identified from a communication channel. In a second case hard symbols are identified from the communication channel. According to the Application:

> The reduced state MLSE equalizer 32 processes the communication signal to generate a plurality of soft symbols at an output thereof. Each of the soft symbols has a probability associated with it that represents the probability that the soft symbol is the actual symbol that was transmitted (i.e., for a particular input symbol). The soft symbols are delivered to the symbol selection unit 34 which selects the K most probable symbols from the soft symbols (where K is a positive integer). The K most probable symbols are then output as the reduced alphabet to the reduced alphabet MLSE 36. Application pg. 5, lines 19-26, referring to FIG. 2.

It is well-known in the art that a soft symbol is a vector-like quantity with a magnitude and a direction. The direction represents the state of the symbol or bit, e.g., a group of ones and zeros, or a phase of an electrical signal representing a particular combination of ones and zeros, for example. The magnitude is a real number representing a probability, a likelihood, or a reliability associated with the symbol.

The enabling statement from Applicant's Specification "[t]he soft symbols are delivered to the symbol selection unit 34 which selects the K most probable symbols from the soft symbols" discloses the process of creating a reduced alphabet by selecting a subset of symbols using a probability value inherent with each soft symbol. The real numbers representing probabilities associated with the reduced alphabet subset are indicative of higher probabilities than real numbers associated with symbols not selected as members of the reduced alphabet. Thus, the symbol probability information comprising the reduced alphabet selection criteria is attached to each symbol in the form of a real number as the symbols arrive at the symbol selection unit 34. The symbol selection unit 34 "selects the K most probable symbols" by comparing the real number representing the probability of each symbol equalized by the reduced complexity (the first) equalizer against the real numbers probabilities of all the other symbols equalized by the reduced complexity equalizer.

Applicant's Specification also enables a selection of a reduced alphabet for the case of hard symbols, as follows:

> [T]he equalization system 40 includes a hard decision equalizer 42, a symbol selection unit 44, and a reduced alphabet MLSE 46. An optional alphabet size determination unit 48 may also be provided. The hard decision equalizer 42 processes the communication signal to generate a hard symbol for each of the input symbols. *The symbol selection unit 44 then selects the K-1 symbols from the full alphabet that are closest in distance to the hard symbol.* These K symbols are then output as the reduced alphabet. Specification pg. 6, lines 10-16, referring to FIG. 3. (Emphasis added.)

As is well-known in the art, coding distance refers to a characteristic of a symbol that is capable of differentiating that symbol from other symbols in a symbol set. Take a sample case of 8PSK phase modulation, for example. 8PSK is capable of encoding a three-bit symbol. All possible 8PSK symbols form a circle of dots on a phase constellation diagram. A dot representing a symbol is located on each of the real and imaginary axes and at each 45-degree increment between the axes. A symbol at +45 degrees is closer to a symbol at zero degrees than would be a symbol at 90 degrees, for example. Thus, by instructing that "*the symbol selection unit 44 then selects the K-1 symbols from the full alphabet that are closest in distance to the hard symbol*" (emphasis added), Applicant's specification enables the selection of a reduced alphabet by explicitly instructing a selection of a determinable subset of symbols, at pg. 6, lines 14-16. Further information regarding coding symbol distances may be found in Appendix A hereto, in an article titled, "Coded Modulation Schemes," from Broadcast Technology no. 17, Winter 2004.

Because Applicant's Specification enables the Application with methods as described above, using simple numerical comparison structures, withdrawal of the rejection of claims 1-30 is respectfully requested. If the Office is not satisfied that Applicant's Specification is sufficiently enabled as to a reduced alphabet determination, Applicant respectfully requests that the Office point out with specificity, in light of the foregoing explanation and prior to issuing a final Office Action, what elements the Office feels are missing from the description of the reduced alphabet determination structures and methods that would be required to practice the invention. Applicant feels that to so pinpoint any outstanding issues will help to advance the prosecution of this case.

§102 Rejection of the Claims

Claim 28 was rejected under 35 USC § 102(e) as being anticipated by Kakura et al. (U.S. 6,366,612, hereinafter "Kakura"). Applicant does not admit that Kakura is prior art, and reserves the right to swear behind these references in the future.

The Office states that

> "Kakura discloses a communication device, see Fig. 1, comprising ;
> means (106) for receiving a communication signal from a communication channel
> means (107) for determining a reduced symbol alphabet that are more likely to be an actual transmitted symbol than other symbols and
> a full-state MLSE equalizer (109) for processing the communication signal based on the reduced symbol alphabet. See col.6, line 58 - col.7, line 6 in particular."

It is respectfully noted that anticipation under 35 USC § 102 requires the disclosure in a single prior art reference of each element of the claim under consideration. *See Verdegaal Bros. V. Union Oil Co. of California,* 814 F.2d 628, 631, 2 USPQ 2d 1051, 1053 (Fed. Cir. 1987). It is not enough, however, that the prior art reference discloses all the claimed elements in isolation. Rather, "[a]nticipation requires the presence in a single prior reference disclosure of each and every element of the claimed invention, *arranged as in the claim.*" *Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co.*, 730 F.2d 1452, 221 USPQ 481, 485 (Fed. Cir. 1984) (citing *Connell v. Sears, Roebuck & Co.*, 722 F.2d 1542, 220 USPQ 193 (Fed. Cir. 1983)) (emphasis added). "The *identical invention* must be shown in as complete detail as is contained in the ... claim." *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 USPQ2d 1913, 1920 (Fed. Cir. 1989); MPEP § 2131 (emphasis added).

Applicant cannot find any reference in Kakura to applicant's claim element of "a means for determining, for individual input symbols within said communication signal, a reduced symbol alphabet having symbols that are more likely to be an actual transmitted symbol than other symbols." In fact, a thorough search of Kakura reveals no reference at all to a "reduced symbol alphabet." Neither can Applicant find in Kakura any reference to "a full-state MLSE equalizer for processing the communication signal based on a reduced symbol alphabet." In fact, a thorough search of Kakura reveals no reference at all to either an MLSE or to a "maximum likelihood sequence estimation" equalizer or technique. The Office analogizes block 109 of FIG. 1 in Kakura to Applicant's reduced alphabet MLSE, and block 107 in Kakura to Applicant's

reduced alphabet determination block. However, block 109 in Kakura feeds block 107. This is inconsistent with Applicant's specification, which describes the output of the reduced alphabet determination block as an input to the reduced alphabet MLSE.

In summary, Kakura does not teach Applicant's independent claim 28 for at least these reasons. Applicant respectfully requests that the Office withdraw the rejection of claim 28. If, after considering Applicant's reasoning, the Office continues to assert anticipation of Applicant's claim 28 based upon Kakura, it is respectfully requested that the Office describe with particularity, for each element of claim 28, how Kakura is identical to Applicant's invention as embodied in claim 28, in order to advance the prosecution in a timely manner.

Conclusion

Applicant respectfully submits that the claims are in condition for allowance and notification to that effect is earnestly requested. The Examiner is invited to telephone Applicant's attorney Bruce Houston at (210) 508-5355 to facilitate prosecution of this application.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,
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Date April 17, 2006 By Bruce E. Houston
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Reg. No. 55,280

CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being transmitted via facsimile (571-273-8300) to: MS Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on this 17th day of 2006.

Bruce E. Houston | Bruce E. Houston

Name | Signature

Appendix A

Lecture

Technologies and Services of Digital Broadcasting (10)

Coded Modulation Schemes

As described in previous issues, there are two main parts of digital transmission technology: digital modulation technology that converts a digital signal into a transmission signal, and error correction technology that overcomes errors caused by noise and/or distortion arising on a digital transmission path. These two fields have traditionally been researched independently. Coded modulation, on the other hand, can be viewed as an error correcting technology that integrates the above technologies giving particular consideration to non-uniform errors caused by multi-phase/multi-level modulation.

In multi-phase/multi-level modulation, the separation between signal points (symbols) in a constellation used for transmitting information may vary. Figure 1 shows these differences between symbol distances for various modulation schemes. As can be seen from the figure, the symbol distances of each modulation scheme are different. In QPSK, for example, the transmission of symbol S_0 is more likely to be erroneously received as S_1 or S_3 than as S_2. In 8PSK, diagonally placed symbols can maintain a distance of at least 2.6 times that of adjacent symbols.

Generally for coherent detection, the probability $p(x)$ of the error distance x between the received symbol and transmitted symbol is a Gaussian distribution expressed as follows.

$$p(x)=\frac{1}{2\pi N}e^{-\frac{x^2}{2N}} \qquad (1)$$

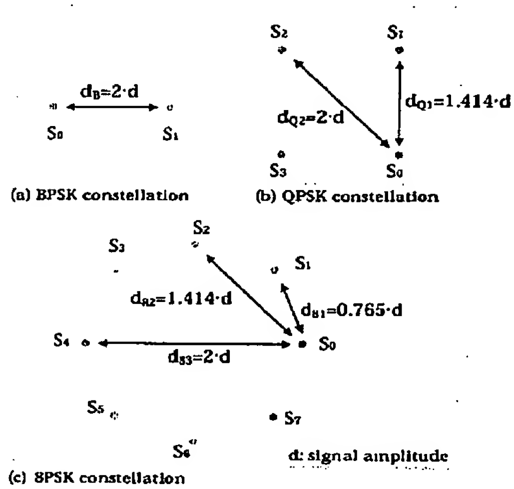


Figure 1: Difference in symbol distance

Here, N is noise variance. Figure 2 shows the probability density function for error in the distance between the received symbol and transmitted symbol. Denoting the distance between adjacent symbols as A, an error occurs when x becomes larger than $A/2$. Accordingly, the error probability P_e becomes

$$P_e=\int_{\frac{A}{2}}^{\infty} p(x)dx \qquad (2)$$

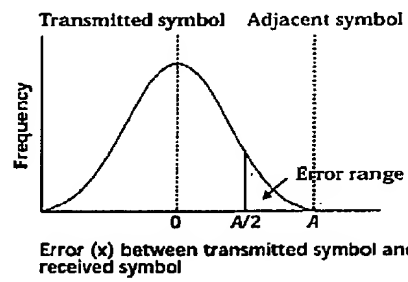


Figure 2: Probability density in distance between received symbol and transmitted symbol

Figure 3 shows P_e when normalizing the inter-symbol distance A by N. This plot tells us that the error rate with respect to inter-symbol distance decreases monotonically. For example, a normalized inter-symbol distance of 4 means an error rate of about 2×10^{-2}. For example, a normalized inter-symbol distance of 4 corresponds to an error rate of 2×10^{-2}, which is not conductive to digital transmission, while at or above 2.6 times this distance (10.6), the corresponding error rate is 10^{-7}. That means the difference of error rate is five orders of magnitude.

In light of the above, uniform error correction might not

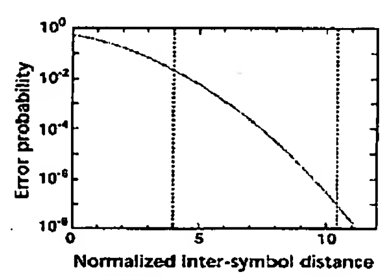


Figure 3: Error probability for normalized symbol distance

work effectively for a modulation scheme in which error occurrence is different depending on symbol distance. For this reason, the effectiveness of error correction that takes into account the symbol arrangement in a digital signal has come to be emphasized, beginning with Ungerboeck in 1976 and 1982 and Imai and Hirakawa in 1977. There has since been extensive research on coded modulation that integrates modulation and error correction.

1. Set Partitioning

A coded modulation scheme applies non-uniform error correction to non-uniform symbol distances for multi-phase/multi-level modulation. In other words, it applies error-correcting codes having different error-correcting capabilities. We recall here that multi-phase/multi-level modulation is characterized by the transmission of multiple bits per symbol. A specific technique of allocating bits when applying codes having different error-correcting capabilities is "set partitioning."

Figure 4 shows the bit allocation by set partitioning as proposed by Ungerboeck, taking 8PSK modulation as an example. This technique is as follows.

(1) Divide adjacent symbols on the 8PSK constellation into two groups, allocating 0 or 1 to the LSB (a_1) of each symbol, depending on the group.

(2) As each of these two groups consists of four symbols (corresponding to QPSK), divide adjacent symbols in each group in the same way as step (1), allocating 0 or 1 to the 2nd bit (a_2) of each symbol, depending on the group.

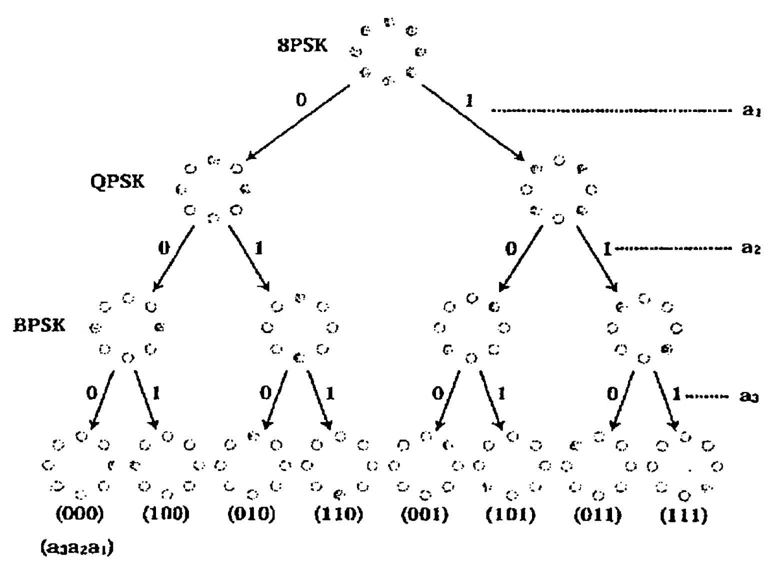
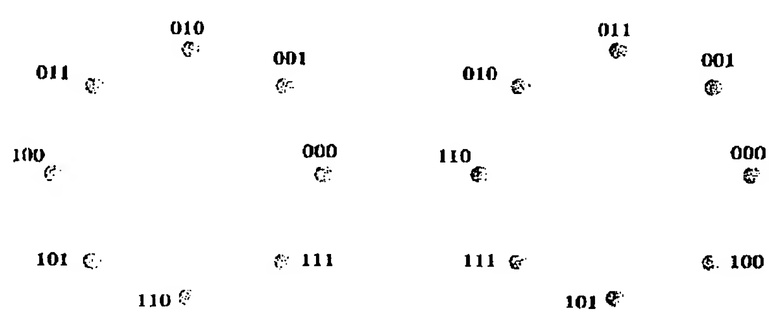


Figure 4: Set partitioning technique



(a) Bit allocation by set partitioning (a) Bit allocation by gray coding

Figure 5: 8PSK symbol arrangement charts

(3) As each of the resulting four groups consists of two symbols (corresponding to BPSK), again divide adjacent symbols in each group into two groups allocating 0 or 1 to the MSB (a_3) of each symbol, depending on the group.

Allocating bits by partitioning in this way reveals the following.

(1) Errors for bit a_1 can easily occur, because adjacent symbols of 8PSK will necessarily have different a_1s.

(2) If a_1 is assumed to be correct, then a_2 changes every other symbol of 8PSK and a symbol distance the same as that of QPSK will be obtained.

(3) If a_1 and a_2 are assumed to be correct, then a_3 can be determined if a decision can be made as to which diagonal symbol has been received, and a symbol distance the same as that of BPSK will be obtained.

This means that if a_1 can be guaranteed by using robust error-correcting code, characteristics equivalent to those of QPSK can be obtained, and if a_2 can be guaranteed, characteristics equivalent to those of BPSK can be obtained.

Bit allocation in the past has also made use of gray coding. Figure 5 shows the 8PSK symbol arrangement charts made by set partitioning and gray coding. Bit allocation using gray coding means that adjacent symbols differ by only one bit, that is, an arrangement in which the Hamming distance is 1. In this case, there is no difference in the ways that errors occur in bits a_1, a_2, and a_3.

Figure 6 shows the configuration of an 8PSK modulator using coded modulation, and Fig. 7 shows that of a conventional 8PSK modulator. Mapping A in Fig. 6 performs bit allocation by set partitioning. In this case, robust protection of bit a_1 is important, as described above. In the conventional modulator of Fig. 7, on the other hand, error correction code acts on each bit in a uniform manner, making it difficult to employ differences in correction capabilities. For this reason, bit allocation using gray coding provides better characteristics in Mapping B.

2. Coded Modulator and Its Characteristics

As shown by Fig. 6, bits in multi-phase/multi-level modulation may be transmitted using error-correcting codes of differing capability, which means that various schemes can be considered for coded modulation. One of these, proposed by Ungerboeck, exhibits superior characteristics through trellis-based decoding. Figure 8 shows the configuration of this scheme. In relation to Fig. 6, this scheme enables the use of coded modulation with 1/2 convolutional code for error-correcting codes 1 and 2.

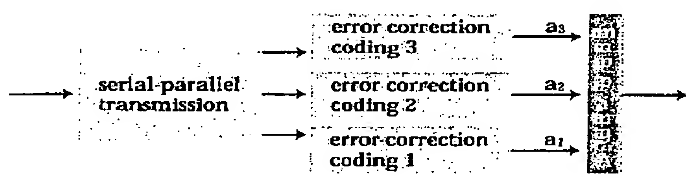


Figure 6: Configuration of an 8PSK modulator using coded modulation

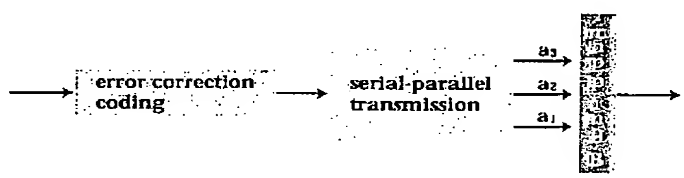


Figure 7: Configuration of a conventional 8PSK modulator

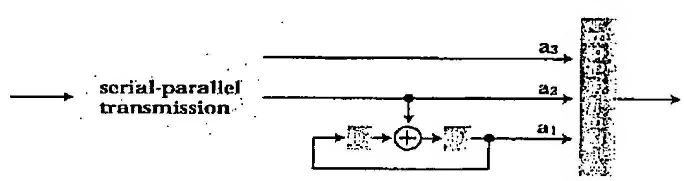


Figure 8: Configuration of an Ungerboeck coded modulator

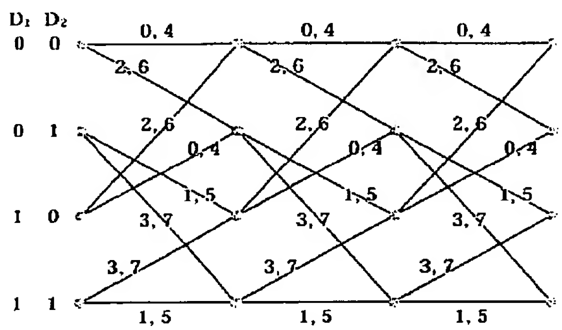


Figure 9: Decoding Trellis diagram for the Ungerboeck coded modulator

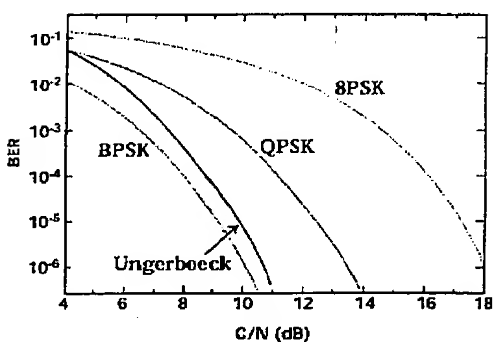


Figure 10: Performance of coded modulation using convolutional code

The use of convolutional code, in turn, makes possible Viterbi decoding using a Trellis diagram on the receive side. Figure 9 shows such a decoding trellis diagram. The numerals in the figure indicate symbols with (a_3, a_2, a_1) denoted in decimal. For example, 0=(0 0 0), 4=(1 0 0). As can be seen from Fig. 8, a_3 is not coded, which means that it cannot be distinguished in the decoding of error-correcting code. For this reason, two symbols with different a_3's are shown on the same line on the Trellis diagram, for example, (0,4) or (2,6). The metric or decoding criterion here is the square Euclidean distance from the received symbol to each symbol.

Figure 10 shows the characteristics of coded modulation using convolutional code. This plot reveals that the Ungerboeck scheme asymptotically approaches BPSK performance in the range for which 1/2 convolutional code can be sufficiently corrected. The transmission bit rate per Hertz of Ungerboeck coded modulation is the same as that of QPSK, which means that the transmission power for obtaining the same error rate as QPSK can be made smaller by 3 dB.

(Dr. Toru Kuroda)